DRAFT TECHNICAL MEMORANDUM

BDCP EIR/EIS Water Quality Sensitivity Analysis

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This technical memorandum provides a summary of the sensitivity analysis performed to ascertain if the water quality compliance issues identified in the public draft BDCP EIR/EIS (DEIRS) are a result of the assumed operational assumptions in addition to the limitations of the modeling tools used.

Background and Objective

SWRCB D-1641 (D-1641) water quality control standards are included in the modeling of the DEIRS. However, modeling results presented in the DEIRS showed exceedances of the standards at several locations, both under DEIRS baselines as well as the Alternatives, including:

- Agriculture salinity compliance in Sacramento River at Emmaton
- Agriculture salinity compliance in San Joaquin River at San Andreas Landing
- Agriculture salinity compliance in Old River at Tracy Road Bridge
- Fish and Wildlife salinity compliance in San Joaquin River at Prisoners Point
- Fish and Wildlife salinity compliance in Suisun Marsh

Modeling sensitivity runs were formulated to examine if the documented exceedances are a result of the limitations associated with the modeling tools or potential project related impacts. The sensitivity analysis was limited to the DEIRS Existing Condition, No Action Alternative, and Alternative 4 H3.

Key Assumptions for DEIRS Alternatives Considered

DEIRS Existing Condition reflects current climate and hydrologic conditions and includes USFWS and NMFS Biological Opinions (BiOps), except for the Fall X2 action. DEIRS No Action Alternative (NAA) reflects Late Long-Term, or LLT conditions (about year 2060), increased demands, climate change and sea level rise, in addition to the BiOps. DEIRS Alternative 4 H3 LLT (Alt4 H3) is consistent with NAA except the San Joaquin River inflow to export ratio action of the NMFS BiOp is not included. Alt4 H3 also includes:

- Proposed 9,000 cfs North Delta Diversion
- Additional Oct – Jun OMR based south Delta export restrictions
- Head of Old River Barrier operations
- Proposed Fremont Weir improvements
- Year-round Rio Vista minimum flow requirement
- 65,000 acres of Delta marsh restoration, and
- D-1641 Sacramento River compliance at Emmaton relocated to the confluence with Threemile Slough.

DEIRS Salinity Modeling Approach

DEIRS salinity impacts were analyzed based on the modeling results from CALSIM II and DSM2 simulations of the DEIRS baselines and Alternatives. A detailed description of the modeling tools and approach is provided DEIRS Appendix 5A.

CALSIM II is a water operations model that simulates Delta flows for regulatory and operational criteria assumed under baselines and the Alternatives on a monthly time step. The model simulates compliance with salinity standards in the Delta. CALSIM II relies on an "Artificial Neural Network" (ANN) for monthly averaged flow verses salinity relationships in the Delta.

DSM2 uses the monthly CALSIM II Delta flow results, and simulates Delta hydrodynamics and salinity from the water year 1976 to water year 1991, on a 15-minute time step and accounts for the sea level rise and the proposed restoration. Flow inputs assumed in DSM2 modeling for EIRS are based on monthly CALSIM II outputs downscaled to a daily time step using WY 1976 – 1991 (16 years) historical flow patterns as shown below in Figure 1. The daily patterns assumed are based on observed historical Delta flows, and do not represent any sub-monthly operational adjustments that could occur to address any potential issues with salinity control in the Delta under the DEIRS Alternatives.

Daily averaged salinity outputs from DSM2 simulations were used to evaluate compliance with salinity standards in the DEIRS.

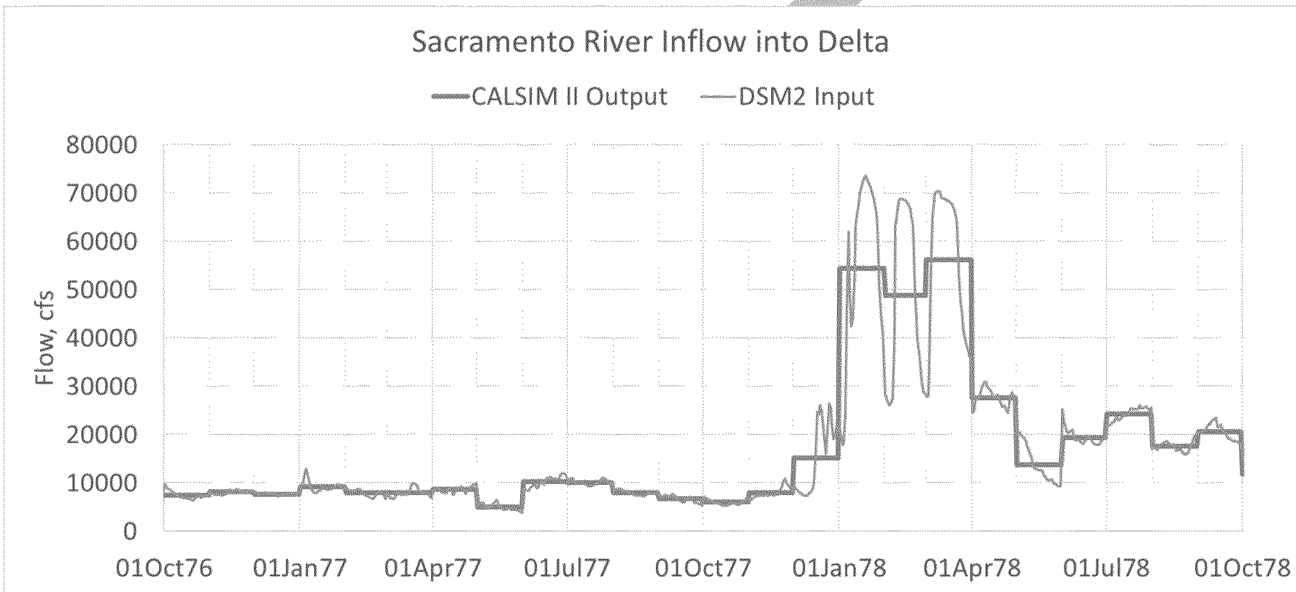

Figure 1: Example Plot Comparing Monthly Sacramento River Inflow to the Delta Resulting from CALSIM II Model, and assumed Daily Patterned Sacramento River Inflow in the DSM2 Model in the DEIRS.

Sensitivity Analyses and Findings

Sensitivity runs were formulated based on the key modeling assumptions used for the DEIRS Alternatives and the salinity modeling approach used, to identify the reason for reported exceedances.

To explain exceedances at Emmaton the following sensitivity runs performed:

- CALSIM II run of Alt4 H3, with salinity compliance at Emmaton, and corresponding DSM2 salinity simulation;
- DSM2 run using CALSIM II output for Alt4 H3 with compliance at Emmaton without the daily patterning of Delta inflows.

Additional variations of DEIRS Alt4 H3 DSM2 runs were simulated to explain exceedances at other compliance locations, including

- removing daily patterning of Delta inflows in Alt4 H3 DSM2 run
- Alt4 H3 DSM2 run with Montezuma Slough Salinity Control Gate (SCG) operations consistent with the NAA
- Alt4 H3 DSM2 run with NAA SCG operations, and removing 65,000 acres restoration
- Alt4 H3 DSM2 run with NAA Head of Old River Barrier operations.

Threemile Slough vs Emmaton Compliance

As noted above, CALSIM II modeling of Alt4 H3 in the DEIRS assumed shifting the D-1641 salinity compliance at Emmaton to Threemile Slough. CALSIM II results for the sensitivity run, Alt4 H3 with the compliance location at Emmaton instead of Threemile Slough, show minor changes in the system operations with slightly more upstream releases, more Delta Outflow and less Delta Exports. Also, Delta exports are shifted by a small volume to the south Delta intakes. Figure 2 shows the average annual Delta exports by water year type for the Alt4 H3 with compliance at Threemile Slough as in DEIRS and at Emmaton. Overall, the differences are negligible with slight reduction in the below normal and dry years. The shift in compliance location was found to affect the compliance with D-1641 salinity standards in Sacramento River at Emmaton, San Joaquin River at San Andreas Landing, and San Joaquin River at Prisoner's Point.

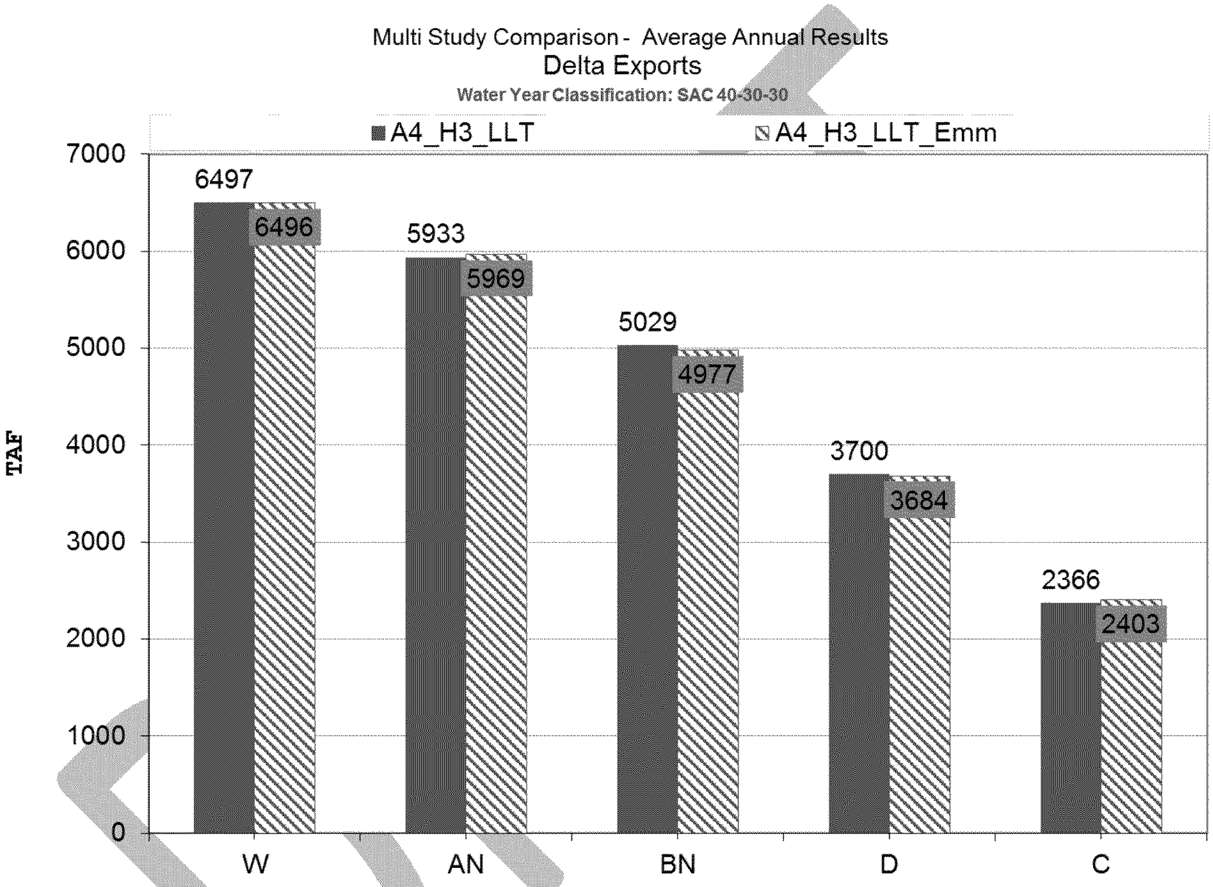

Figure 2: Comparison of Average Annual Delta Exports for Alternative 4 H3 with Compliance at Threemile Slough and at Emmaton.

Emmaton Exceedances

Table 1 compares the percentage of days with modeled Emmaton salinity exceeded the compliance standard under the DEIRS Existing Condition, NAA and Alt4 H3, with Alt 4 H3 sensitivity run with compliance at Emmaton instead of Threemile Slough. Top row shows the percentage of time Emmaton standard was exceeded when DSM2 inflow inputs are daily patterned as in the DEIRS, and the bottom row shows the same value when DSM2 inflows did not include daily patterning. The values in Table 1 show number of days with modeled exceedance expressed as a percentage of days when Emmaton standard is active, which is 2192 days during WY 1976 - 1991. Overall, assuming the compliance location at Emmaton instead of Threemile Slough in the CALSIM II modeling allowed exceedances at Emmaton decrease from 28% to 15% under Alt4 H3, and brought the remaining exceedances a lot closer to the NAA, which has 13% exceedances. Daily patterning of the DSM2 inflow inputs had less influence on the exceedances.

TABLE 1

Emmaton Salinity Compliance Exceedances

Percentage of days exceeding compliance standard during WY 1976-1991 (2192 days)

DSM2 Inflow Assumption	BDCP DEIRS Alternatives			H3_LLT with compliance at Emmaton Sensitivity Run
	EX	NAA_LLT	H3_LLT	
with daily patterning	6%	14%	28%	16%
without daily patterning	4%	<u>**13%**</u>	28%	<u>**15%**</u>

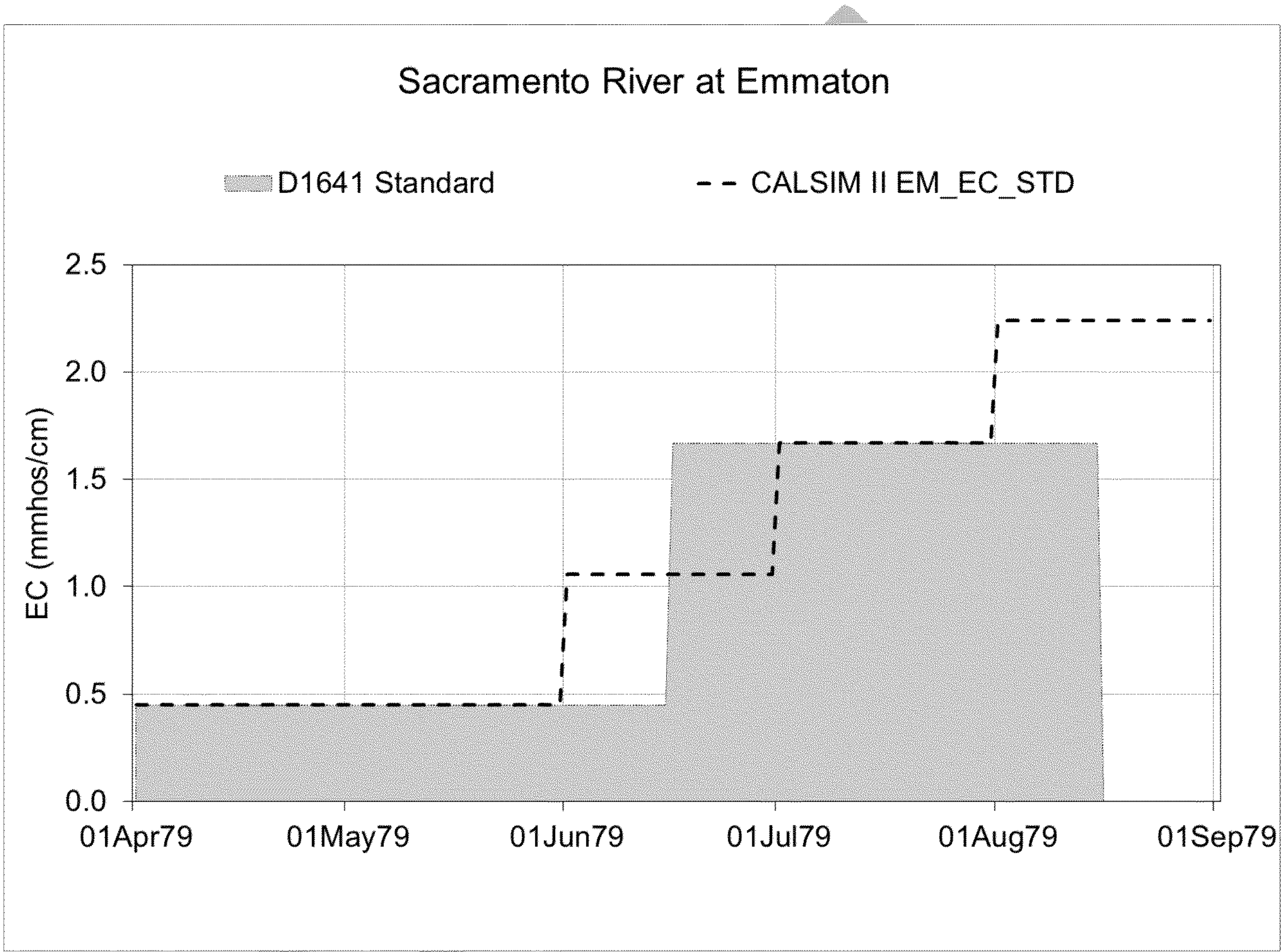

Figure 3: D-1641 Salinity Control Requirement at Emmaton as Simulated in CALSIM II

Remaining exceedances under NAA and Alt4 H3 are primarily a result of the CALSIM II limitations. Since CALSIM II is a model with a monthly time-step and a number of daily D-1641 standards are active during only portions of a month (ex: April 1 – June 20 and June 20 to August 15), D-1641 standards are calculated as a monthly weighted average. When the monthly weighted average standards calculated for CALSIM II are less stringent than the daily D-1641 EC standards, CALSIM II adjusts SWP and CVP operations to release less flow to meet monthly weighted average EC standards instead of the flow needed to meet higher daily D-1641 EC standards. Figure 3 shows the difference between daily D-1641 EC standards and the monthly weighted average EC standards modeled in CALSIM II. Therefore, within the months where the salinity standard is transitioning, there may be days where DSM2 inflows are less than the required to comply with the salinity standard, and more than on other days. This results in a few days within such months where the modeled salinity is exceeding the compliance standard. However, in reality the CVP and SWP operations will be adjusted on day-to-day basis to meet the Delta standards. Figures 4 to 6 show examples of salinity exceedances during the months with transitions in the standards.

Table 2 summarizes the reasons for the remaining Sacramento River at Emmaton exceedances. As explained above, most of the remaining exceedances are a result of a transition in EC standards within a month and the inability of CALSIM II model to respond to a transitioning standard within a given month. In some months, unavailability of the flow to meet the salinity standards in the Delta when upstream storage is at deadpool conditions was a factor for the exceedances at Emmaton. Other months have exceedances that are insignificant (having only a few days of exceedances, surpassing the standard only by 0.7 mmhos/cm or less) when considering the uncertainty in the CALSIM II/DSM2 model accuracy. There are a few months where the Emmaton standard is exceeded under NAA, Alt4 H3, or both, and the reason for the exceedance is not fully clear. It may be due to the uncertainty in the CALSIM II's ANN to predict the amount of flow needed to meet the salinity requirement. Given that upstream storage in these months under NAA, Alt4 H3, or both is available, it is not unreasonable to assume that CVP and SWP operators would adjust the upstream releases to meet the salinity conditions in the Delta, based on the real time conditions.

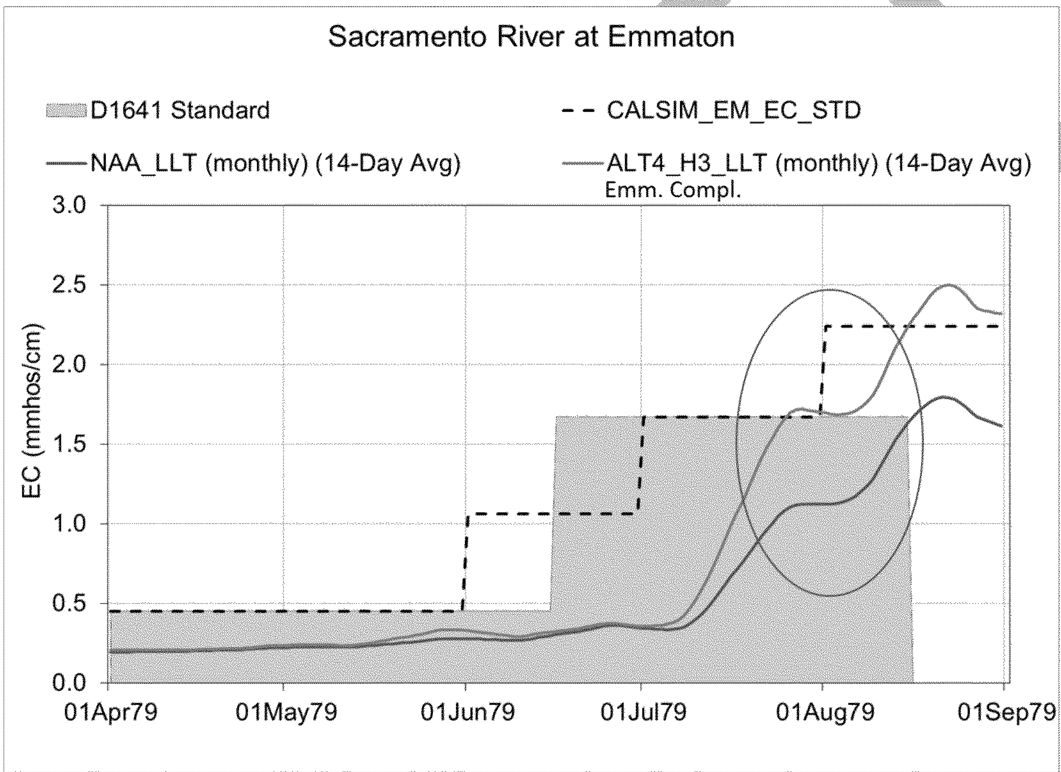

Figure 4: Simulated Salinity at Emmaton Compared to D-1641 Standard for Year 1979

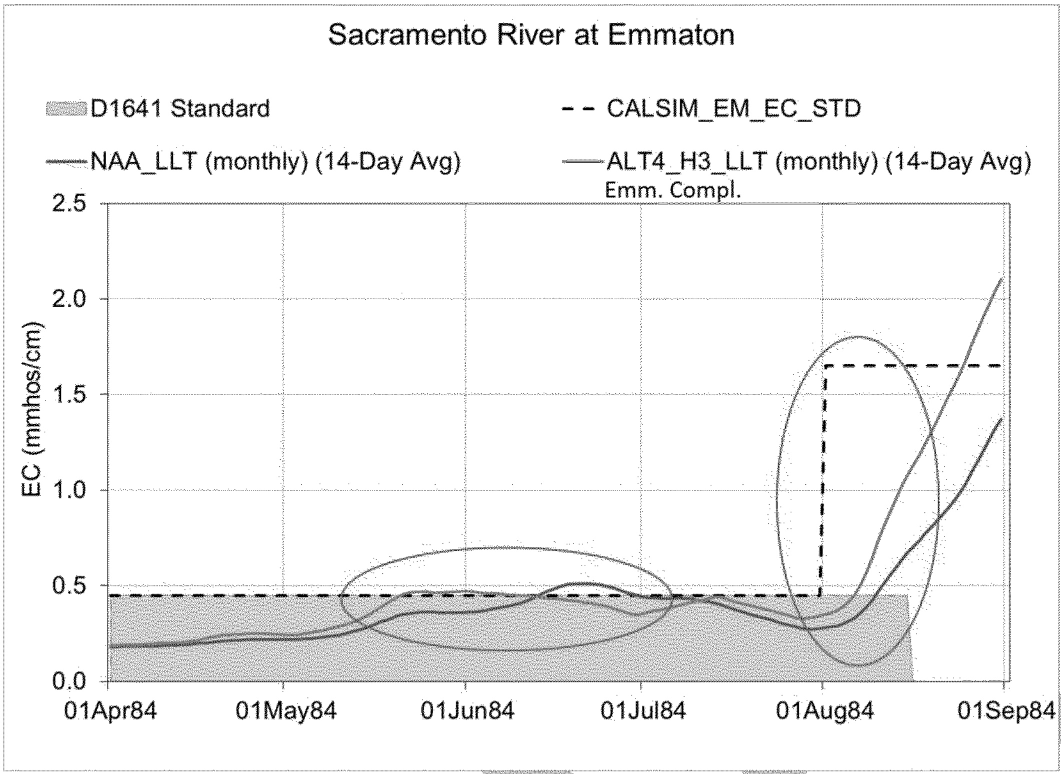

Figure 5: Simulated Salinity at Emmaton Compared to D-1641 Standard for Year 1984

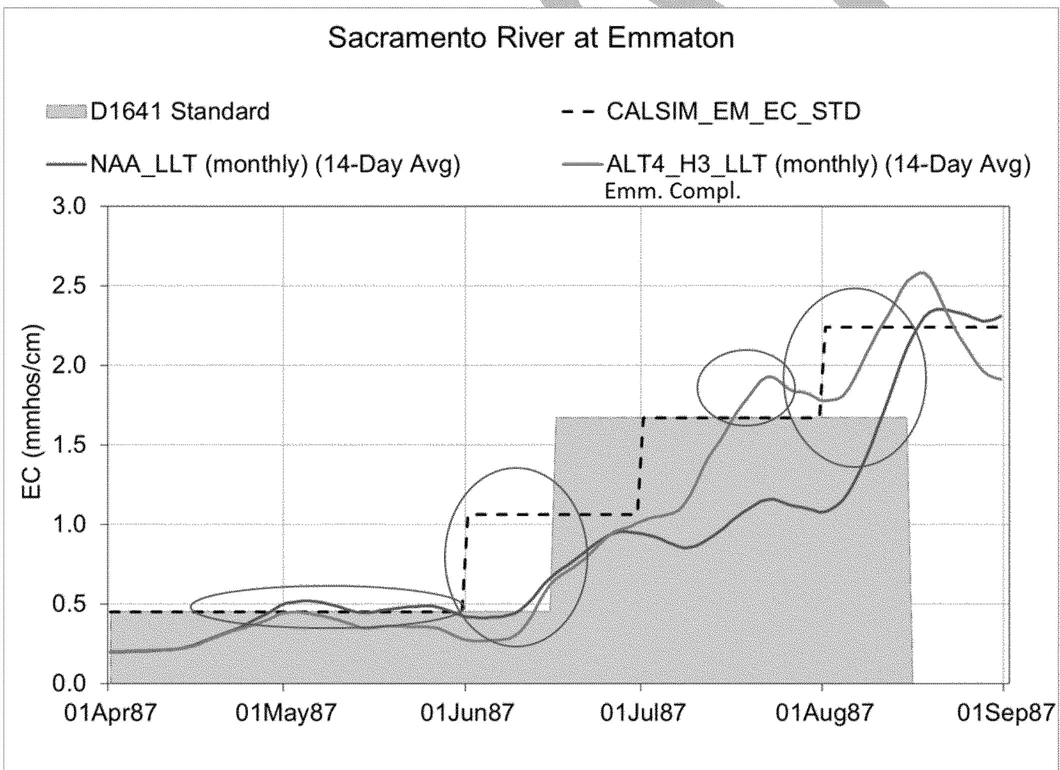

Figure 6: Simulated Salinity at Emmaton Compared to D-1641 Standard for Year 1987

TABLE 2
Emmaton Standard Exceedances
Modeled Monthly Performance under NAA_LLT and Alt 4 H3 (with Emmaton Compliance)

WY	WYT	Apr	May	Jun	Jul	Aug	Notes
1976	D	T		T	U	T	Alt4 H3 violation end of August
1977	C			d4, d8	d4, d8	d4, d8 T	d4, d8 for both NAA and Alt4 H3; T only for NAA
1978	AN					T	
1979	D				s (0.05)	T	s - 0.05 mmhos/cm (1.67)
1980	AN			T		T	few violations during transition at end of June
1981	D		T	T		d8, T	d8 for Alt4 H3 only; many violations during transition in mid-June for NAA, few for Alt4 H3
1982	W					T	
1983	W					T	
1984	W		s (0.02)	s (0.06)		T	s - 0.02 mmhos/cm (0.45 standard); s - 0.06 mmhos/cm (0.45)
1985	BN	s (0.04)		T			s - 0.04 mmhos/cm (0.45)
1986	W			U	U	T	
1987	D		s (0.07, 0.04)	T	U	T	s - 0.07 mmhos/cm (0.45) and s - 0.04 mmhos/cm (0.45) in May; few violations during transition in mid-June; Alt4 H3 violation end of Aug.
1988	C				U	U	Alt4 H3 violation end of Aug.
1989	D			T	U	U	few violations in transition in mid-June
1990	C			U	d4, d8		d4 and d8 for Alt4 H3 only
1991	C			U			

Notes: Grey – Alt4 H3 LLT (with compliance at Emmaton), Pink – NAA monthly, White – both scenarios, s – exceeds compliance by approximately 0.05 mmhos/cm or less, T – transition in EC standards, U – unresolved, d - deadpool at Shasta (4), Oroville (6), or Folsom (8)

San Andreas Landing Exceedances

San Andreas Landing had very few exceedances in the DEIRS modeling as shown in Table 3. Table 3 below shows number of days with modeled exceedances expressed as a percentage of days when the standard is active, which 2,192 days during WY1976 – 1991. Removing the daily patterning resolved the NAA exceedances completely, and reduced the Alt4 H3 exceedances by half. The small number of the remaining exceedances under Alt4 H3 are found to be small in magnitude and only during a few days in a month as shown in the Figures 7 and 8, and can be addressed in the real time operations.

TABLE 3
San Andreas Landing Salinity Compliance Exceedances
Percentage of days exceeding compliance standard during WY 1976-1991 (2192 days)

DSM2 Inflow Assumption	BDCP DEIRS Alternatives			H3_LLT with compliance at Emmaton Sensitivity Run
	EX	NAA_LLT	H3_LLT	
with daily patterning	1%	1%	6%	4%
without daily patterning	0%	<u>**0%**</u>	<u>**3%**</u>	2%

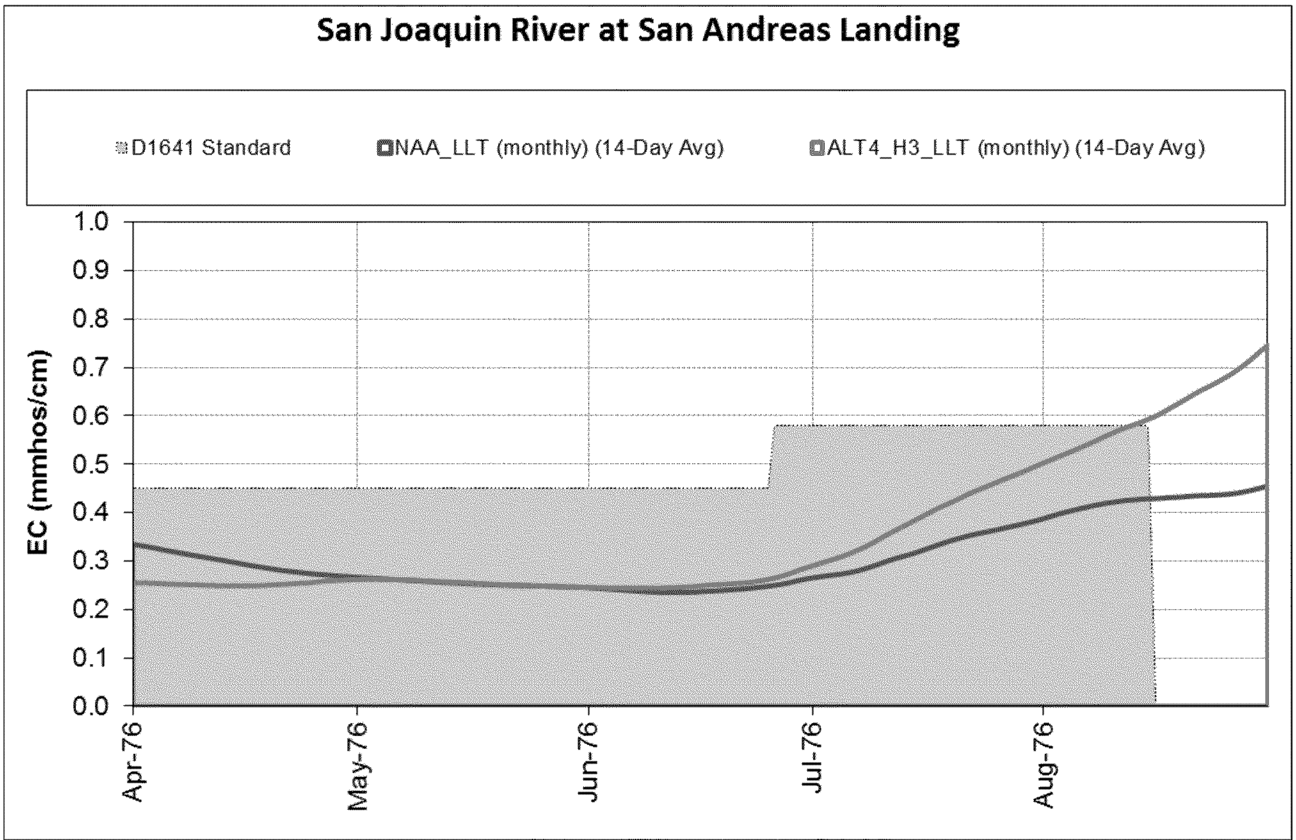

Figure 7: Simulated Salinity at San Andreas Landing Compared to D-1641 Standard for Year1976

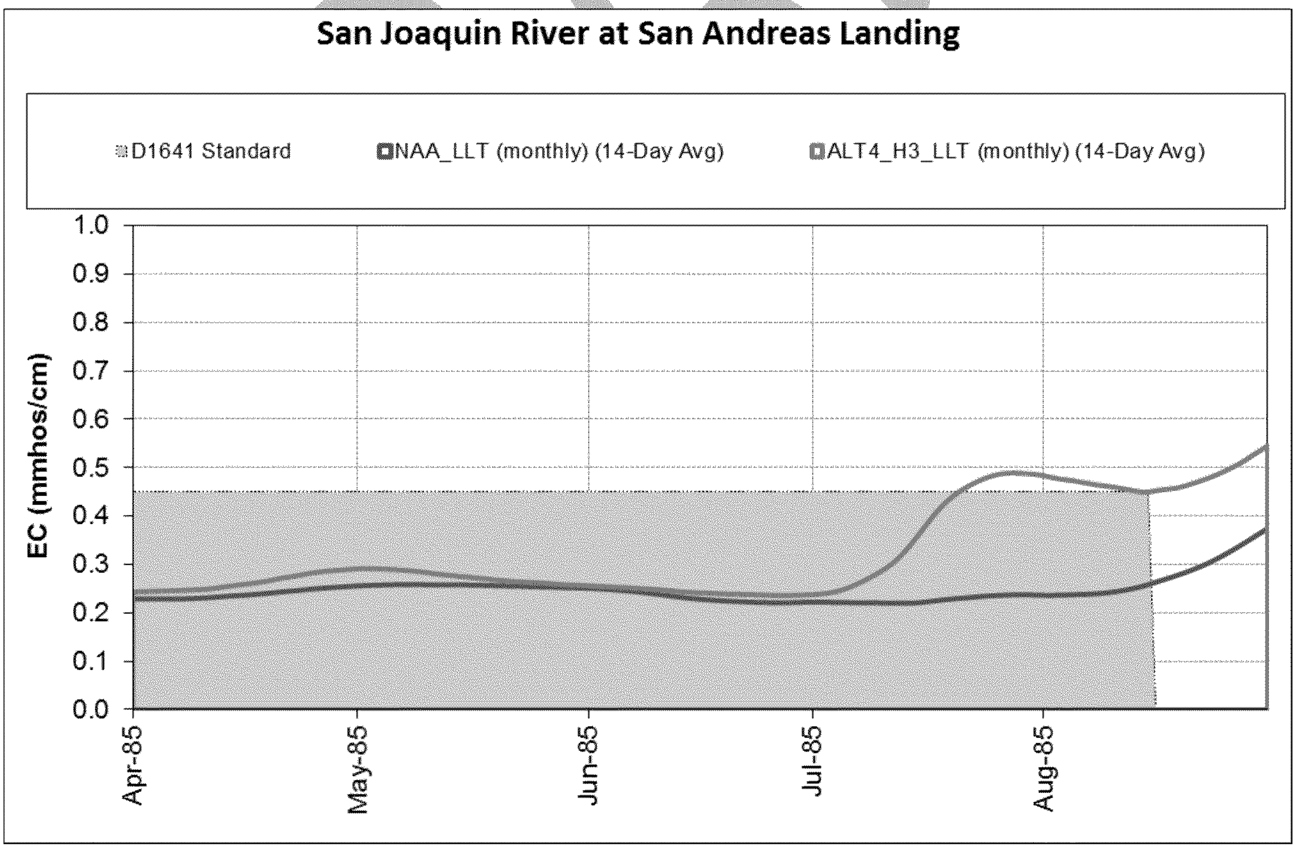

Figure 8: Simulated Salinity at San Andreas Landing Compared to D-1641 Standard for Year 1985 (BN)

Old River at Tracy Exceedances

Table 4 shows that removing daily patterning of the DSM2 inflows resolved some of the Old River at Tracy exceedances. Remaining exceedances under NAA and Alt4 H3 are mostly in the drier years, and during early summer months. These may be a result of the differences in the south Delta temporary barrier assumptions in the drier years, and may be resolved by modeling temporary barrier operations consistent with historical dry year practices of installing earlier in the year. The Old River at Tracy standard is active for 5,750 days during WY1976 – 1991. Table 4 below shows number of days with modeled exceedances expressed as a percentage of days when the standard is active.

TABLE 4
Old River at Tracy Exceedances
Percentage of days exceeding compliance standard during WY 1976-1991 (5750 days)

DSM2 Inflow Assumption	BDCP DEIRS Alternatives			H3_LLT with compliance at Emmaton Sensitivity Run
	EX	NAA_LLT	H3_LLT	
with daily patterning	4%	4%	6%	5%
without daily patterning	4%	4%	5%	5%

San Joaquin River at Prisoner's Point Exceedances

Prisoner's Point exceedances remained under all sensitivity analyses performed for Alt4 H3, even though exceedances are reduced when the restoration is removed. This is potentially due to the HORB assumption differences, and South Delta export differences between A4 H3 and NAA. The Prisoner's Point standard is active for 732 days during WY1976 – 1991. Table 5 below shows number of days with modeled exceedance expressed as a percentage of days when the standard is active for various sensitivity runs.

TABLE 5
San Joaquin River at Prisoner's Point Exceedances
Percentage of days exceeding compliance standard during WY 1976-1991 (732 days)

DSM2 Inflow Assumption	BDCP DEIRS Alternatives			H3_LLT with compliance at Emmaton Sensitivity Run	H3_LLT with SCG	H3_LLT with SCG and No Restoration	H3_LLT with HORB open in Apr-May
	EX	NAA_LLT	H3_LLT				
with daily patterning	5%	1%	22%	22%	-	-	-
without daily patterning	5%	0%	22%	22%	23%	13%	17%

Suisun Marsh Salinity

As shown in Figures 9 and 10, making the salinity control gate operations under Alt4 H3 to be consistent with NAA, Suisun Marsh salinity was found to be closer to NAA; however, still high during October through May. Removing the restoration under the Alt4 H3 resolved this, which suggests that restoration may be contributing the higher salinity under Alt4 H3, and refining the restoration footprints may help resolving this issue to an extent.

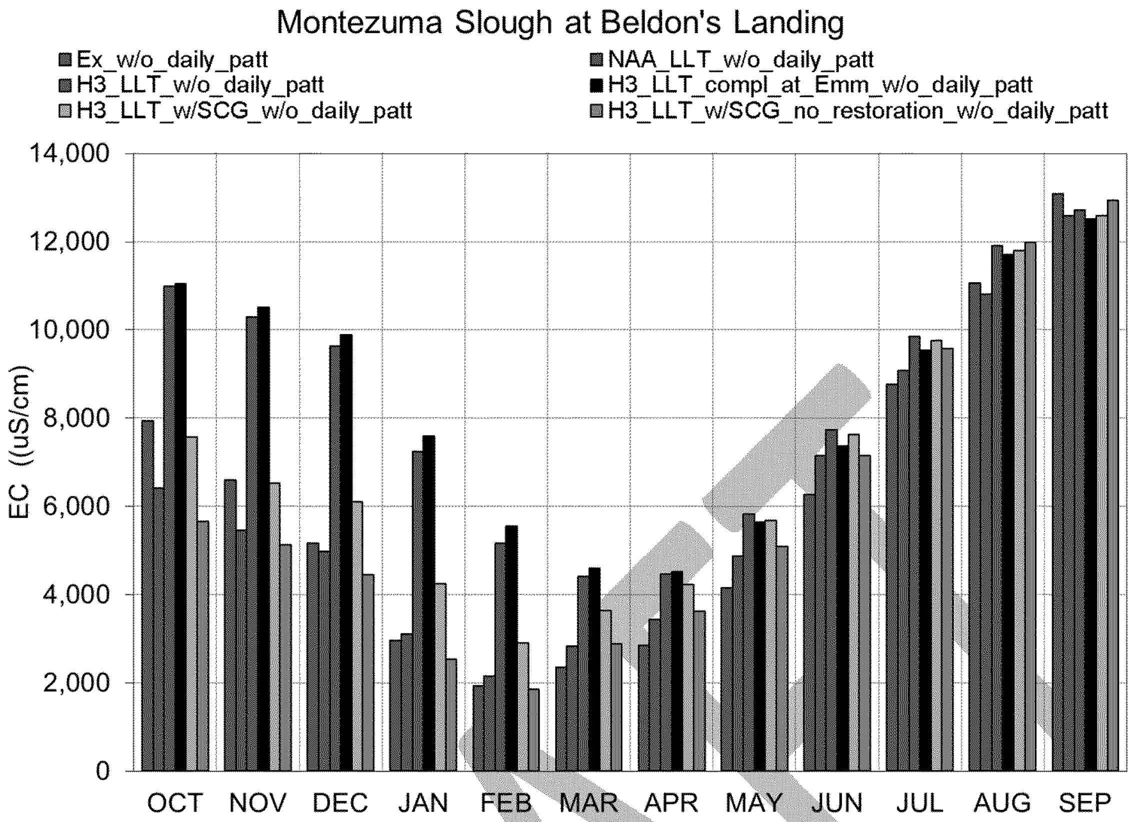

Figure 9: Modeled Monthly Average EC at Montezuma Slough at Beldon's Landing Averaged over WY 1976-1991

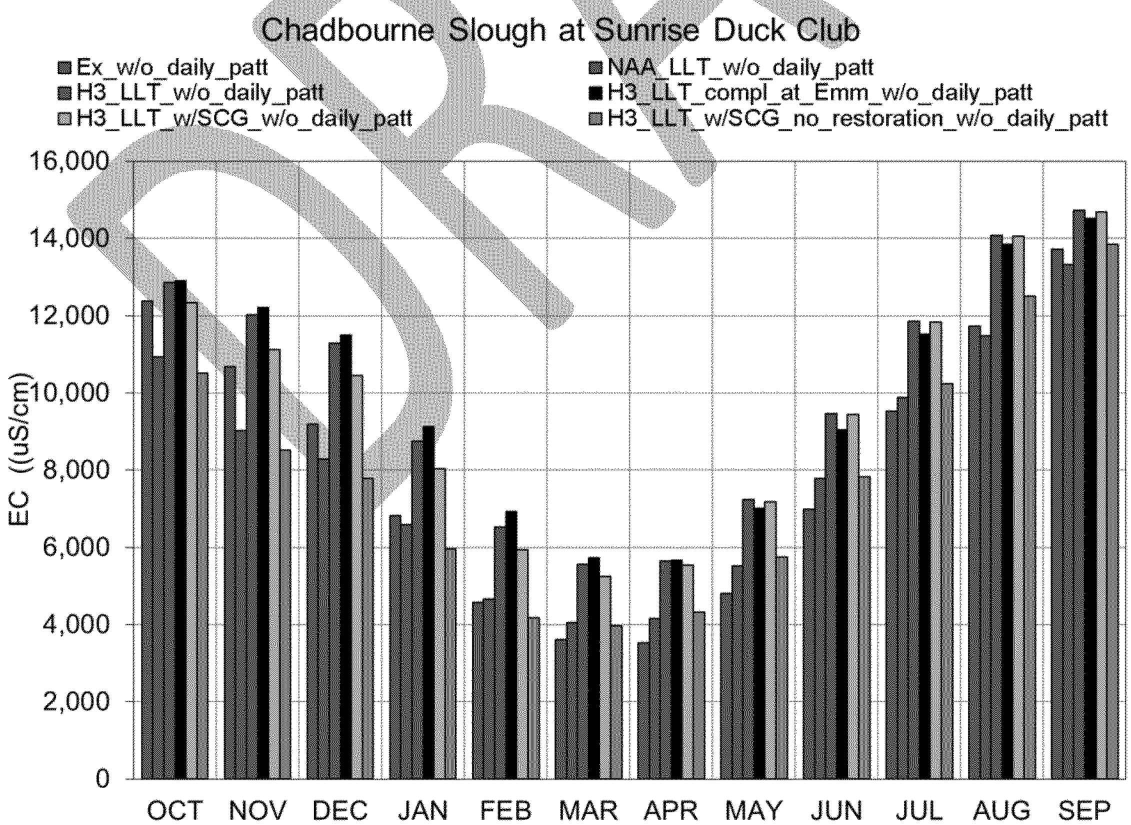

Figure 4 Modeled Monthly Average EC at Chadbourne Slough at Sunrise Duck Club Averaged over WY 1976-1991

Summary

Several sensitivity runs were modeled to determine if the reported salinity exceedances in the DEIRS are because of a limitation in the modeling tools. As explained above majority of the exceedances are because of the assumed operational criteria under DEIRS Alternatives. For example, modeled exceedances at Emmaton under Alt4 H3 are comparable to NAA, once the compliance location was assumed to be at Emmaton instead of Threemile Slough as assumed in the DEIRS. Another example is the Suisun Marsh Salinity Control Gate operations assumed under Alt4 H3 in the DEIRS. The sensitivity runs point to modeling limitations for the remaining exceedances.